VŠB – Technical University of Ostrava
Faculty of Mechanical Engineering
Department of Energy Engineering

Návrh snížení hluku dieselgenerátoru
Design of Reducing the Noise of the Diesel Generator

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VŠB - Technical University of Ostrava
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Diploma Thesis Assignment

Student: **Murali Mahesh Ramasamy, BE**

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Title: Design of Reduce the Noise of the Diesel Generator
Návrh snížení hluku dieselgenerátoru

The thesis language: English

Description:

Create a design solution to reduce the diesel generator noise using oil pan insulation. Create a suitable oil pan insulation cover design, realize its production and verify the assumed impact on noise production by real measurement.

Content of the diploma thesis:
1. Background research in the field of noise reduction in combustion engines for mobile and stationary applications.
2. Structural design of insulating cover.
3. Design drawing of insulating cover.
4. Realization of insulating cover and verification of assumption of noise reduction by measuring on a real diesel generator.
5. Proposal for further measures to reduce noise in a stationary combustion engine.

References:

STONE, Richard. Introduction to internal combustion engines. 3rd ed. Warrendale, Pa.: Society of Automotive Engineers, c1999. ISBN 978-0768004953.
GUPTA, Aman, Shubham SHARMA a Sunny NARAYAN. Combustion engines: an introduction to their design, performance, and selection. Salem, Massachusetts: Scrivener Publishing, [2016]. ISBN 9781119284512.
XIN, Qianfan. Diesel engine system design. Cambridge: Woodhead Publishing, 2011. Woodhead Publishing in mechanical engineering. ISBN 978-1-84569-715-0.
TŮMA, Jiří. Vehicle gearbox noise and vibration: measurement, signal analysis, signal processing and noise reduction measures. Chichester: Wiley, 2014. ISBN 978-1-118-35941-9.
CROCKER, Malcolm J. Handbook of noise and vibration control. Hoboken, N.J.: John Wiley, c2007. ISBN 9780471395997.

Extent and terms of a thesis are specified in directions for its elaboration that are opened to the public on the web sites of the faculty.

Supervisor: **Ing. Petr Pavlík, Ph.D.**

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DIPLOMA THESIS ANNOTATION

Murali Mahesh, R. *Design of Reduce the Noise of the Diesel Generator: Diploma Thesis*. Ostrava: VŠB - Technical University of Ostrava, Faculty of Mechanical Engineering, Department of Energy Engineering, 2019, 62 p. Thesis head: **Pavlík, P.**

This Diploma thesis is focused on practical methods of reducing noise levels in IC engine. Noise reduction is one of the highest prior targets for IC engine development because of increasingly stringent engine noise limits. After burning the fuel the many poisonous exhaust gas such as $CO2$, $SO2$, $NO2$, are generated, such types of harmful exhaust gases are generate noise and air pollution. In this paper the noise measurement of diesel generator is described by different method like as design of an oil pan cover and insulating cover technique described. Polystyrene insulating cover is a device which is used for reducing the amount of noise emitted by an internal combustion engine. It is an acoustic soundproofing device designed to reduce the noise of the sound pressure created by the engine.

ANOTACE DIPLOMOVÁ PRÁCE

Murali Mahesh, R. *Návrh redukce hluku dieselového generátoru: Diplomová práce*. Ostrava: Vysoká škola báňská - Technická univerzita Ostrava, Fakulta strojní, Katedra energetiky, 2019, 62 p. Thesis head: **Pavlík, P.**

Tato diplomová práce je zaměřena na praktické metody snižování hladin hluku v IC motoru. Snížení hluku je jedním z nejvyšších prioritních cílů pro vývoj motorů s vnitřním spalováním z důvodu stále přísnějších hlukových limitů. Při spalování kapalných paliv ve spalovacím motoru vzniká mnoho jedovatých výfukových plynů, jako je $CO2$, $SO2$, $NO2$, tyto druhy škodlivých výfukových plynů znečištění ovzduší. V této diplomové práci je ověřena možnost snížení hluku dieselového generátoru metodou konstrukce izolačního krytu víka olejové vany. Izolační kryt z polystyrenu slouží ke snížení množství hluku emitovaného z vnitřního prostoru spalovacího motoru. Jedná se o akustické zvukově izolační zařízení určené ke snížení hladiny akustického hluku produkovaného motorem.

CONTENT

LIST OF USED SIGNS AND SYMBOLS

S.No	Symbols	Abbreviation	Units
1	L'_{pA}	Average sound pressure level	**[dB]**
2	K_{1A}	Background noise correction	**[dB]**
3	K_{2A}	Eligibility Criterion for Test Environment	**[dB]**
4	K_{3A}	Local area correction	**[dB]**
5	**U**	Expanded measurement uncertainty	**[dB]**
6	**A**	A value characterizing the environment properties	**[m]**
7	**D**	Distance of operator movement from measured device	**[m]**
8	**S**	Area of measured surface	**[m^2]**
9	**p**	Emission sound pressure	**[dB]**
10	L_p	Emission sound pressure level	**[dB]**
11	$L_{p,T}$	Time-averaged emission sound pressure level	**[dB]**
12	p_{peak}	Peak emission sound pressure	**[dB]**
13	$L_{p,peak}$	Peak emission sound pressure level	**[dB]**
14	L_E	Single event emission sound pressure level	**[dB]**
15	$D_{I,op}$	Work station directivity index	**[1]**
16	$D_I^* op$	Apparent work station directivity index	**[1]**
17	$D_I^* op, approx$	Approximate apparent work station directivity index	**[1]**
18	d	Typical distance	**[1]**
19	Hz	Hertz	**[1]**
20	RPM	Revolutions Per Minute	**[1]**
21	EGR	Exhaust Gas Recirculation	**[1]**
22	dB	Desibel	**[1]**
23	KW	Kilowatt	**[1]**

1 INTRODUCTION

A noise is generally harmful and serious health hazards, with the need of our modern society for various machines for human, comfort, fast travel and appliance for routine job in home and office has led to increase in the level of noise pollution almost. The harmful effect of high noise level can cause hearing losses. The insulating oil pan cover is an acoustic sound profile design to reduce the loudness or highly intensive sound of the sound pressure created by the engine.

Engine head noise are major contributors to the overall noise pollution and need to be significantly reduced. In this paper reduction of noise from the diesel generator is discussed. In particular, reduction of noise from the oil pan region targets. This study investigates the health and physiological effect of generator noise and also the design, fabrication and installation of the oil pan cover. The measurement of noise level is carried out by Brüel&Kjær model 2250 under Czech/European standards. Two types of measurement has to be taken - one without oil pan cover and another with oil pan cover. The change of noise level will be noted down. Finally there will be the discussion to reduce the noise from the other parts of the engine [1].

2 ENGINE NOISE

Pulses release by the exhaust is the cause of engine noise. When expansion stroke of engine comes near the end, outlet valve opens and the remaining pressure in the cylinder discharges exhaust gases as in pulse into the exhaust system. These pulses are between 0.1 and 0.4 atmospheres in amplitude, with pulse ration between 2 and 5 milliseconds. The frequency spectrum is directly correlated with pulse duration. The cut-off frequency lies between 200 and 500 Hz. Generally, engines produce noise of 100 to 130 dB depending on the size and type of the engine [1].

2.1 Classification of Engine Noise Source

- Engine head noise
- Exhaust system noise
- Intake system noise
- Cooling system noise
- Engine surface radiated noise

2.1.1 Engine Head Noise

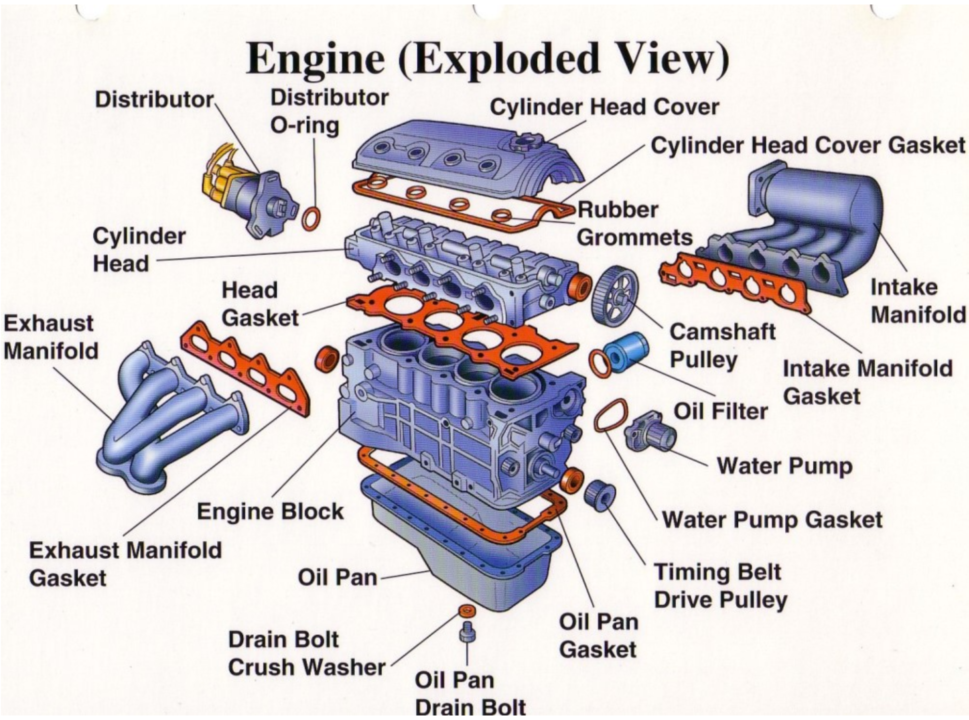

Fig. 1 - IC Engine

Source: http://www.bringyourownparts.com/wp-content/uploads/2018/05/engine.jpg

- Valve Train Noise
- Timing Chain Noise
- Detonation, Pre-ignition (Pinging) Noise
- Connecting Rod Noise
- Crankshaft Bearing Noise
- Piston Slap
- Piston Pin Noise
- Whining Noise

Valve Train Noise

The noise of the valve and the aerial lifter has a tapping sound that generally calms down as shown in Fig. 1.1 upgrade the RPM motor. The intake and exhaust valves are opened and closed by a lifter. These sounds can be triggered by hydraulic lifters worn or sticking. In most instances, a varnish built up on lifting surfaces triggered sticking lifts. Low petroleum stress (which would lead a hydraulic lifter to crash) could also trigger them.

Sticking issues with the lifter can be achieved many times by incorporating petroleum detergent additives. If this does not eliminate noise, then it would involve substitute for worn lifts that continue to create noise. This is not an simple or inexpensive task and a qualified auto repair engineer will have to do it [2].

Timing Chain Noise

Many of the latest motors have long timing lines overhead camshafts. A timing chain links the crankshaft to the camshaft to ensure that at the right moment doors are opened. Hydraulic tensioners typically held the slack in those strings close. The chains are riding against a nylon guide (a chain guide) that starts wearing in moment. The timing chain starts to shake at the stage where chain guides are carried beyond the hydraulic tensioner's capacity to pick up the slack. This sound was triggered by timing strings becoming so loose that against instructions and potentially timing cover they swing back and forth.

If the petroleum stress were right, it would be necessary to replace hydraulic tensioners and chain guides. A stethoscope of a mechanic was a excellent instrument to identify this sound. It would be necessary to verify and repair the issue if the sound was loudest when pressing the timing cover with the stethoscope disassembly. For most of these motors, this was a semi-major task and would generally price four digits [2].

Detonation, Pre-ignition (Pinging) Noise

When you accelerate the car, you generally hear that sound. Most individuals call it a noise of pinging or snapping. That sound was triggered by a pressure pressure prematurely activated air / fuel blend in the motor car as the piston moved up on the pressure stroke. If ignition occurs before liquid hits the bottom of its stroke, it was referred to as pre-ignitionor pre-detonation, which could harm pistons, valves and tubes. They get harmed because the ignition of petrol too soon generates strain waves in the tank due to the gas explosion that collides with the car as it moves up. And that's why you're hearing sounds pinging and scratching.

Some of the triggers of this situation are incorrect octane petrol, overheating of the motor, incorrect ignition timing, failure of the EGR valve and computer or touch detector issues. All of these circumstances can trigger air gas blend to ignite in cylinders before various flame fronts are created in cylinder battling each other and creating pinging and clicking sound. Check the handbook of your owner to create sure you use the correct petrol grade or you might change for a duration to a greater grade and see if noise is gone. If not, you're going to want to look at those other feasible triggers [2].

Connecting Rod Noise

Excessive clearance between crankshaft and linking rod bearing surface triggered the connection of rod noise. This occurs when you had poor petroleum stress causing dry lubrication of the engine, which in turn would harm the surfaces of the engine and the crankshaft. That could also be triggered at frequent intervals by bad maintenance methods such as not altering petroleum. The petrol becomes filthy and the grit could scratch the engines surface. The sound you hear was a bang to the engine's underside. Usually, when you keep the throttle at constant RPM, the sound was heard. If it sounds like a single knock, you (or your mechanic) might isolate the cylinder for each cylinder one at a time by disabling the spark or fuel injector. You've discovered the issue when sound passes away or becomes much louder. Problems such as this involve instant attention as ongoing motor operating in this situation would harm the crankshaft and involve significant motor revision. The law of thumb was that once you hear sound, there was a strong likelihood that you would need significant motor job in four price ranges. [2].

Crankshaft Bearing Noise

Low petroleum pressure harm to bearing surfaces has also induced crankshaft bearing noise and can ultimately harm the crankshaft itself. This sort of noise was generally defined in the accelerating motor as bubbling or throbbing sound. If that noise has been heard, it is highly essential not to operate the motor again until the petroleum bin has been removed and the handles of the crankshaft are checked. Motor could be saved in many instances if crankshaft was not harmed. By replacing bearings and fixing petroleum pressure issue, a mechanic would solve the issue. Bearing shells is the inward rotation of the crankshaft. If you keep running the motor with that situation, you'd most likely cause a significant motor failure. It was also a strong chance that you could hear the sound that it might be too late to save without changing the motor. This could be a costly four-figure repair [2].

Piston Slap

This sound was triggered by unnecessary clearance of a tank wall between the piston skirt and was generally discovered on cars with elevated mileage. Cracks in the reduced piston skirt were the normal source of this issue. The piston cap was the reduced component of the piston that, owing to steel exhaustion, would grow splits over moment. The sound tastes like a silent clock sound or a silent clatter deep in the motor, and when the motor was cold it was more visible. When the motor warms up, nothing requires to be achieved if the sound passes away. If the sound is lowered when the temperature of the motor increases but does not go away, the most probable solution is to replace the cylinder itself. There was really nothing you can do to avoid this issue and, fortunately, it's not a repair work as severe as some of the above [2].

Piston Pin Noise

The sound of the piston lock was comparable to that of the valve locomotive. The noise was distinctive due to the absence of fuel and unnecessary clearance between valve grip and piston causing you to hear a double knocking sound. A piston button binds the shaft to the cylinder. It was lubricated by spraying water on the lock through a gap in the coupling tube of the opposing cylinder. Only by replacing piston pin bushings, potentially even piston itself, together with fixing petroleum stress or lubrication issue, could this situation be remedied. Problems such as this generally lead from worn rod and crankshaft bearings that reduce petroleum stress. If you had this issue, a large four-figure motor job would lead cost range [2].

Whining Noise

A whining sound when an motor generally runs an indication of a bearing on the brink of failure. As motor RPMs rise, that noise will improve.

When rotating the steering wheel from side to side, whining from the energy steering tank would become louder and the normal cause was poor energy steering liquid. The easiest route to diagnose other sounds from the belt was with the stethoscope of a mechanic. Failure to repair any of the products that make a whining noise might cause a car to break down. Not only that, but when parts with bearings ultimately fall apart, other motor components could be harmed. So getting that kind of issue checked out is a intelligent concept. Spend little cash now to save a great deal of cash later [2].

2.1.2 Exhaust System Noise

Noise from the exhaust scheme includes noise from exhaust gas shocks that enters muffler or path tube and sound produced from the exhaust unit component's touching ground. Noise transferred from the fuel unit element surface is the consequence of two distinct excitation force types. These have been produced by the pulsating wind. Gas flow from the vibrating motor to the exhaust system element [3].

2.1.3 Intake System Noise

Intake system noise includes air stream produced by system air inlet and vibrating surface element noise produced. A important attenuation of intake air noise would be provided in many instances in motor air cleaner. If extra attenuation needed, the scheme could be supplemented with an inlet air silencer. To minimize radiated noise from the top of the intake structure, it is vital to properly develop, select and mount the system element [3].

2.1.4 Cooling System Noise

Using a radiator as a thermal exchanger with an axial stream fan, the water-cooled motor was typically cooled to pull warm air through a radiator. Air-cooled motor usually used a centrifugal fan to guide cooling air across the motor in combination with shrouding. Fan noises consist of separate sounds of frequency as well as wide noises of the side. The wide hand part of fan noise was created by spinning fan blade sorties and disturbance in the ventilator air scheme [4].

2.1.5 Water Cooled Engine

A range of layout parameters affect axial stream fans ' noise pollution rate, but the dominant criterion for minimizing fan tip velocity was fan blades tip velocity. While still offering enough cooling of the motor. The efficiency of the cooling system must be as high as possible to maximize the efficiency of the cooling system in water-cooled engines [4].

2.1.6 Engine Surface of Noise

Engine ground noise relates to the sound generated from the touching ground of the equipment for motor components and other items included in the exhaust motor. Intake and cooling system methods used to decrease radiated noise on the motor surface include reducing motor tolerances for operating clearance and machining. Component sound therapy or refurbishment of motor components used for acoustically treated shields and vibrating insulation and damping of motor covers and diesel engines as compared to petrol motor turbo charging of a diesel motor can lead to a decrease in motor surface radiated noise at elevated motor load [5].

2.2. Classification by Noise Characteristics

A typical method for classifying motor noise distinguishes aerodynamic noise, combustion and mechanical noise.

- Aerodynamic noise.
- Combustion noise.
- Mechanical noise.

Aerodynamic Noise

Aerodynamic sound involves noise from exhaust gas and water supply, as well as noise from heating units, supplementary vents or any other air stream [6].

Combustion Noise

Combustion sound relates to sound produced after excitation with gas forces with the touching surfaces of the motor framework, motor parts and motor equipment [6].

Mechanical Noise

Mechanical sound relates to sound produced by the sliding surfaces of motor parts and motor accessories after excitation with reciprocating or rotating motor parts [6].

3 GENERATOR AND NOISE

Generators could be the noisiest thing on the planet, but when you are without power, they are worth gold. A home standby generator or whole house generator comes in different sizes, from 7 KW to 20 KW in air-cooled and 22KW and higher in liquid cooled. Portable generators is other options due to personal considerations and choice. The difference in size and type depend upon ones needs and power demand. Home standby generators has noise level in the range of 62-68 dB depending upon kind of generator one had. Portable generators has much higher decibels than home standby generators. The noise was caused by engine and exhaust of generator [7]. A portable generator could run closer to 90 dB. To define quiet portable generators as those with a decibel level of 60 was somewhat arbitrary, because decibels is on a logarithmic scale, identifying 60 decibels was usually expressed in terms of comparisons with known sound levels in everyday life [8]. For example, a generator running at 60 decibels will be about the same level of sound as will be heard in normal conversation with another person standing within three feet of the listener, so a generator that emits significantly more noise than 60 and 40 decibels create noise pollution. A generator that will block out your ability to hear someone standing or sitting close by will be too loud. There is cases where noise levels are slightly higher than decibel levels advertised by the manufacturer thereby imposing noise pollution to consumers [9].

Fig. 2 - Diesel Generator

Source: Author

3.1 Health and Psychological Effects of Generator Noise

Noise pollution have been used to signify hazard of sound which consequences in modern day development was immeasurable. Noise have numerous health effects making noise pollution a public health concern. The effects include loss of hearing, stress, high blood pressure, sleep disorders,distraction affecting productivity, irritability and in general reduction in quality of life is shown in Fig. 3.2. Sometimes damage is due to long period of exposure or short but at a very high level noise. Once the damage occurs it was irreversible [9], [10]. Below are the detailed effects of generator noise presented under seven categories of advance effect of noise by World Health Organization.

Fig. 3 - Generator and Noise

Source: https://www.thehindu.com/news/cities/bangalore/Living-next-to-the-drone-of-diesel-generator-sets/article16071128.ece

3.1.1 Negative Social Behaviour and Annoyance Reactions

Annoyance was defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her. Perhaps in better description of this response will be aversion or distress. Annoyance increases significantly when noise was accompanied with vibration or with low frequency components. Our generators produce noise that was accompanied with vibrations [11]. The term annoyance does not begin to cover wide range of negative reactions associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. once generators were switch on. Interference with spoken communication was a big challenge generator noise was imposing on residents. This challenge cut across all age groups and sex [11].

3.1.2 Hearing Impairment

A very large proportion of the respondents in each age group is affected by noise emanating from generators. Hard of hearing problem was predominantly between ages 20-39 and it is mostly found in males. Noise induced hearing impairment might be accompanied by abnormal loudness perception (loudness recruitment) distortion (paracusis) and tinnitus. It was important to know that ears do not "get used" to loud noise. As league for the hard of hearing notes - they "get deaf". Prolonged exposure to noise above 85 decibels could cause permanent hearing loss [12].

3.1.3 Sleep Disturbances

Uninterrupted sleep was known to be a prerequisite for good physiologic and mental functioning in healthy individuals. When sleep disruption becomes chronic, results are mood changes, decrements in performance, and other longterm effects on health and well-being. It was known, for example, that continuous noise in excess of 30 db disturbs sleep. Most dwellers is experiencing primary sleep disturbances which is difficulty falling asleep, frequent awakenings, waking too early, and alterations in sleep stages and depth, especially a reduction in REM sleep [13].

3.1.4 Cardiovascular disturbances

Apart from various effects on sleep itself, noise during sleep causes increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction. Studies of individual exposes to occupational or environmental noise show that exposure of sufficient intensity and duration increases heart rate and peripheral resistance, increases blood pressure, increases blood viscosity and levels of blood lipids, causes shifts in electrolytes, and increases levels of epinephrine, norepinephrine and cortisol [14].

3.1.5 Impaired task performance

Decreased alertness leading to accidents, injuries, and death have also been attributed to lack of sleep and disrupted circadian rhythms. The effects of noise pollution on cognitive task performance has been well-studied. Noise pollution impairs task performance at school and work, increases errors, and decreases motivation. Reading attention, problem solving, and memory is most strongly affected by noise [15]. Noise affects learning, reading, problem solving, motivation, school performance, and social and emotional development. There was concern that high and continuous environmental noise might contribute to feelings of helplessness in children [16].

4 INTERNATIONAL STANDARDS FOR MEASUREMENT

Sound power are measured to make objective comparisons but also because legislation requires it. To release a new product, it was often compulsory to certify it according to International Organization for Standardization (ISO) standards as well as local and regional regulations. Apart from certification, sound power testing helps to develop better products in compliance on industry and ISO standards. In fact, it could be enable firms to meet or even exceed expectations, thus improving their competitive advantage and supporting their branding strategy.

4.1 ISO 11202:2010

Acoustics - Noise produced by machinery and equipment - Determination of noise stress concentrations at a job station and at other designated locations with estimated environmental adjustments [17].

ISO 11202:2010 provides a technique for determining the level of noise stress of machinery or appliances, at a job facility and at a specific location. An operator occupied a workstation and could be located in open space, in the room where the source is being tested, in a cab fixed to the source being tested, or in a remote enclosure from the source being tested. These roles are sometimes referred to as standard roles [18].

Levels of noise concentration of emission are determined as concentrations weighted by A. Furthermore, noise stress concentrations in frequency bands and C-weighted maximum output could be determined in compliance with ISO 11202:2010, if necessary [18].

Methods are provided to determine a local environmental adjustment (subject to a defined peak limit value) to be implemented to the measured noise stress concentrations to eliminate the impact of viewing surfaces other than the aircraft on which origin was put under study. This correction was focused on the equal noise intake region of the exam space and the features of radiation (origin place or job site direction) [19].

The technique laid down in ISO 11202:2010 was appropriate for all kinds of noise identified in ISO 12001 (stable, non-stable, fluctuating, remote sound power explosions, etc.) [19].

ISO 11202:2010 was applicable to work stations and other specified positions where emission sound pressure levels are to be measured [20].

4.2 ISO 3746:2010

Acoustics - Determination of sound power rates and sound energy concentrations of noise sources using sound stress - Survey technique using an enveloping surface of measurement over air reflection [21].

ISO 3746:2010 provides techniques for determining the sound power level or sound energy level of a noise source from sound stress concentrations evaluated on a ground enveloping a noise source (machinery or equipment) in a sample setting for which specifications are made. Those readings were used to calculate the sound power amount (or, in the event of noise blasts or intermittent light emissions, the sound energy level) generated by the sound source with frequency A-weighting [22].

The techniques set out in ISO 3746:2010 are appropriate for all kinds of noise identified in ISO 12001 (stable, non-stable, fluctuating, remote sound power explosions, etc.). Information on the variability of the sound power rates and the noise energy concentrations determined in compliance with ISO 3746:2010 was provided for readings produced using A-weighting frequency. The uncertainty is in line with ISO 12001:1996, grade 3 precision (study grade) [23].

4.3 Terms and Definitions

The following conditions and conditions are applicable for the reasons of this paper. More comprehensive terms for particular kinds of devices can be discovered in sound sample codes [24].

Emission sound pressure p

Sound pressure at a work station or other specified position near a noise source when the source is in operation under specified operating and mounting conditions on the reflective plane surface, excluding the effects of background noise as well as the effects of reflections other than those from planes or planes permitted for the purpose of the test.

Note 1 to entry: Emission sound pressure was expressed in pascals [25].

Emission sound pressure level L_p

Ten times the logarithm to the base 10 of ratio of the square of the emission sound pressure, p, to the square of a reference value, p_0, expressed in decibels

$$L_P = 10lg\frac{P^2}{P_O^2}dB \tag{3.1}$$

where the reference value, p_0, was 20 μPa

Time-averaged emission sound pressure level $L_{p,T}$

ten times the logarithm to the base 10 of the ratio of time average of the square of emission sound pressure, p, during a stated time interval of duration, T, to the square of a reference value, p_0, expressed in decibels

$$L_{P,T} = 10lg\left[\frac{\frac{1}{T}\int_{t_1}^{t_2} P^2(t)dt}{P_O^2}\right] dB \tag{3.2}$$

where the reference value, p_0, was 20 μPa

Peak emission sound pressure p_{peak}

Greatest absolute emission sound pressure during a stated time interval

Note 1 to entry: Peak sound pressure was expressed in pascals.

Note 2 to entry: A peak sound pressure might arise from a positive or negative sound pressure [27].

Peak emission sound pressure level $L_{p,\text{peak}}$

Ten times the logarithm to base 10 of ratio of the square of peak emission sound pressure, p_{peak}, to square of a reference value, p_0, expressed in decibels

$$L_{P,Peak} = 10lg\frac{P_{Peak}^2}{P_O^2} dB \tag{3.3}$$

where the reference value, p_0, was 20 μPa

Note 1 to entry: The peak emission sound pressure level was usually C-weighted and denoted by $L_{pC,\text{peak}}$ [27].

Single event emission sound pressure level L_E

Ten times the logarithm to base 10 of the ratio of the integral of the square of the emission sound pressure, p, of an isolated single sound of specified duration, T, to square of a reference value, p_0, normalized to reference time interval $T_0 = 1$ s, expressed in decibels

$$L_E = 10lg\left[\frac{1}{T_0}\int_{t_1}^{t_2}\frac{P^2(t)}{P_0^2}dt\right] dB$$

$$= L_{P,T} + 10lg\frac{T}{T_0} dB \tag{3.4}$$

Note 1 to entry: was equivalent to that for environmental noise descriptor “sound exposure level” (ISO/TR 25417:2007, 2.7) [28].

Work station directivity index $D_{I,\mathrm{op}}$

measure of extent to which a source under test radiates sound in the direction of the work station (operator's position), relative to mean sound radiation over reference measurement surface, expressed in decibels [29].

Apparent work station directivity index $D_I^* op$

$$D_I^* op = L_P^* - \overline{L_P^*} \tag{3.5}$$

where

L_p^* was the sound pressure level measured at the work station, corrected for background noise, but not for influence of the environment;

$\overline{L_p^*}$ was the sound pressure level averaged over the reference measurement surface, corrected for background noise, but not for influence of the environment [29].

Approximate apparent work station directivity index $D_I^* op, approx$

$$D_I^* op, approx = L_P^* - \overline{L_P^*, approx} \tag{3.6}$$

where

L_P^* was the sound pressure level measured at the work station, corrected for background noise, but not for the influence of environment;

$\overline{L_P^*, approx}$ was the sound pressure level averaged over reference measurement surface, corrected for background noise but not for influence of the environment, measured with a reduced number of microphone positions [30].

Typical distance *d*

Distance from the work station to the closest major sound source of the machine under test, without screening objects protruding into line of sight between major sound source and the work station

Note 1 to entry: In the case of extended sound-radiating areas, *d* was the length of the shortest possible line of sight between source under test and the work station [30].

5 THE MEASURING INSTRUMENT - Brüel&Kjær MODEL 2250

Hand-held Analyzer Type 2250 instruction manual, with user manuals, was created to meet the documentation requirements of national and international standards that are shown in Fig. 5.1.

The requirements and additions in this guide include the Hand-held Analyzer Type 2250 and all the software components with the ability to measure or analyze noise intensity. The specific sub-set of specifications configured with a given microphone and software configuration for a given handheld analyzer can be found from the user manual descriptions. It did not support all possible configurations [31].

Fig. 4 - Brüel&Kjær model 2250

Source: https://www.environmental-expert.com/products/brueel-kjaer-model-type-2250-sound-level-meter-15897

5.1 System Overview

• Handheld analyzer type 2250: a portable, one-channel analyzer with a general purpose.

• Handheld analyzer type 2250-L, also known as the 2250 Light: a portable analyzer with low-cost single channel [31].

Type 2250 could be utilized as a single channel noise level meter and frequency analyser with the suitable software components.

Hardware type 2250 could be used in two respects:

1) As a Type 2250 single-channel noise intensity meter and frequency analyzer. The entry was selectable in the customer interface between the two physical lines and the complete level measurement range is addressed in a single spectrum without a level range command. This range is called Single range in the specifications [31].

2) As a dual-channel noise level meter and frequency analyzer with multiple ranges. In this situation it was possible to measure both channels concurrently. These ranges for the least delicate range were called high range in the requirements, and low range for the most delicate scope.

5.1.1 Software Modules

The analyzers are focused on a distinctive platform idea that enables the customer to select distinct computer apps and possibilities combinations. Where necessary, these apps and alternatives could be bought and supplied as readily mounted permits opening in the analyzer the appropriate components of the integrated software. Different combinations of apps and alternatives could be selected depending on the analyzer is shown in Fig. 5.2.

5.1.2 Basic PC Software

Measurement Partner Suite BZ-5503 may be used to transfer fundamental measurement outcomes and configurations between the analyzer and a conventional PC [31]. It was also used in the analyzers to maintain the integrated system is shown in Fig. 5.2.

See the internet assistance of the manual for guidance on this technology.

5.2 Conventions Used in this Manual

If the definition is applicable for all kinds, "Analyzer" relates to Type 2250, Type 2250-L or Type 2270. Icons, buttons and tabs Indicated by courageous face type (for instance, press Main Menu icon) on the screen [31].

Parameter Values, Text and Variables Parameter values, guidelines, screen descriptions and data are model by italics (e.g. internal disk). Menu, Parameters and Screen Navigation Setup > Frequency Settings > BB Peak by courageous type face [31].

5.2.1 Hardware Setup

This section provides an overview of the analyzers ' hardware components.

Hand-held Analyzer Types 2250, 2250-L and 2270 Components required for conformity testing Hand-held Analyzer Types 2250, 2250-L and 2270 Some of the component analyzers also comply with the standards listed in section 4.2 when using alternative components:

• As an alternative to Windscreen UA-1650, Windscreen UA-0237 can be used: It have the same acoustical behaviour but have no auto-detection capability [31].

• As an alternative to Microphone Extension Cable AO-0697-D-100, Microphone Extension Cable AO-0441-D-100 could be used: It is the same cable but the plugs are physically shorter [31].

• As an alternative to Mains Power Supply ZG-0426, the analyzer's power could be supplied by Mains Power Supply ZG-0429, Utility Unit ZH-0689, Utility Unit ZH-0706 (for hardware version 4 only) or Power Panel ZH-0685 with Charger ZG-0857 is shown in Fig. 5.2.

Type 2270 hardware could be utilized in two ways:

1) Types 2250 and 2250-L are a single-channel, single-range sound quality meter and frequency analyzer. Only one channel could be evaluated at a moment in this situation. The entry was selectable in the customer interface between the two physical lines and the complete level measurement range is addressed in a single spectrum without a level range command. This range is called Single range in the requirements [31].

2) As a dual-channel noise level meter and frequency analyzer with multiple ranges. In this situation it was possible to measure both channels concurrently. The complete spectrum of level measurement was discussed with a level range command in two ranges. Theses ranges for the least delicate range were called high range in the requirements, and low range for the most delicate scope [31].

Information on how equipment is used by individual computer components, entry choice for single-channel readings and use of level distance command for dual-channel applications can be discovered in the user manuals [31].

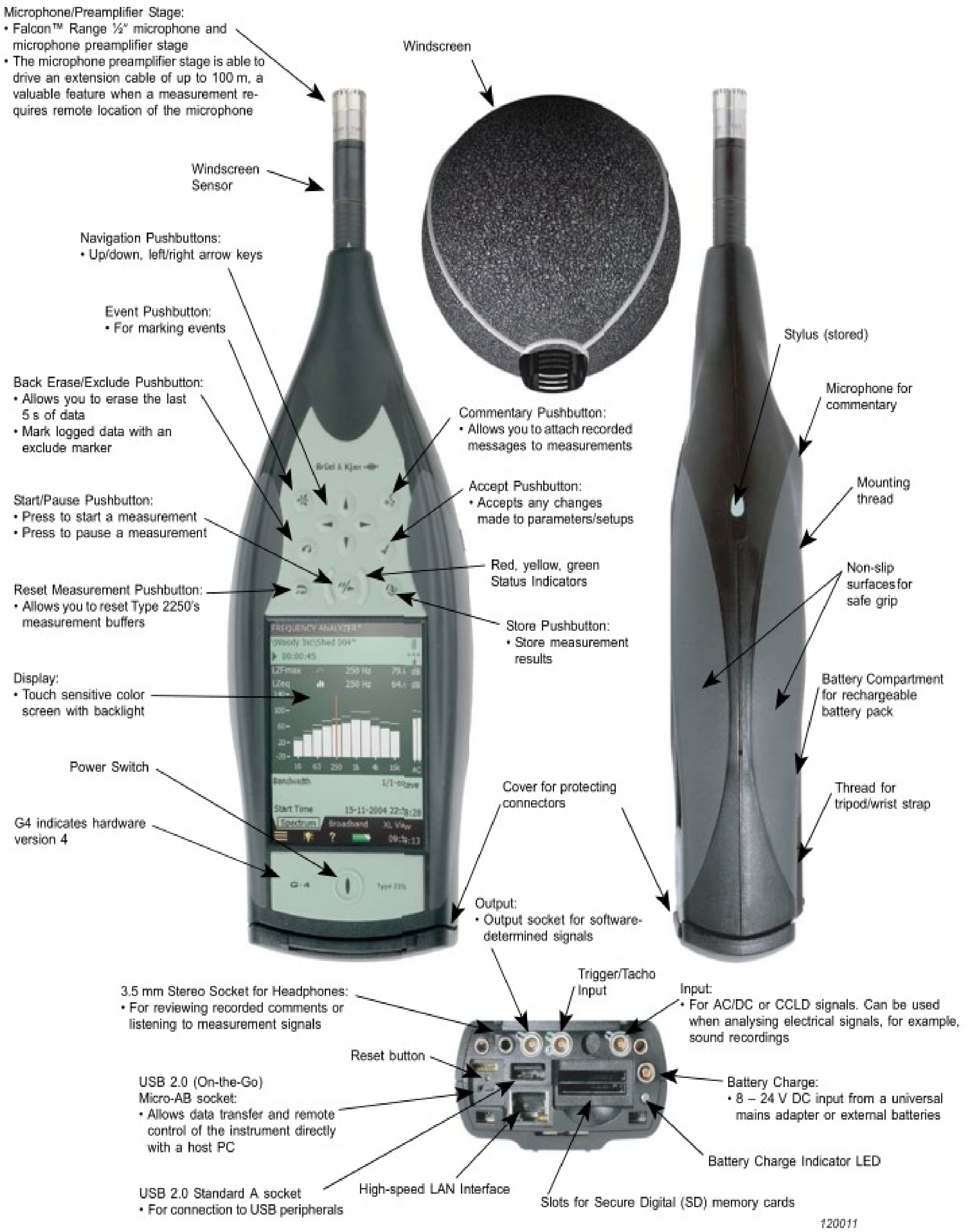

Fig. 5 - Hardware Setup of Brüel&Kjær model 2250

Source: http://www.gracey.co.uk/specifications/bk-2250-s1.htm

6 OPERATING CONDITION OF DIESEL GENERATOR

Table. 1 - Detailed Discription of Diesel Generator

Source: Mielec gas diesel generator

Engine Make	MIELEC GAS
Model	TAD1640GE
Engine Speed	1800 RPM
Tier Rating	Non Compliant
Engine Power Output at rated 1800 rpm	• Kw/m- 445 • HP- 597
Cooling Radiator Cooled Aspiration	Turbocharged / Air to Air
Total Displacement	16.12 Liter
No. of Cylinders and Build 6-inline Bore and Stroke- 144 x 165 mm x mm compression Ratio	17.5:1
Governor Electronic Fuel Consumption (L/hr)	• Full Load- 119.3 • 5% Load- 87.3 • 50% Load- 59.7
Fuel Tank Capacity	755 / 1025(Non-UL) Liters (Open/SAE)
Oil Capacity	48 Liter
Coolant Capacity	93 Liter
Radiator Cooling Air	7.22 m^3/s

Fig. 6 - Noise meter and Generator

Source: Author

6.1 Test Environment (ČSN EN ISO 11202)

Test environment defined in this standard was characterized by three parameters, the size of which was expressed by the appropriate correction.

Criterion for background noise (K_{1A})

The sound pressure level and the background noise, in the sense of CSN EN ISO 11202, averaged over the microphone positions on the measuring surface, shall be at least 3 dB lower than the mean sound pressure level L'_{pA} of the noise source tested in traffic, measured in the presence of those background noise.

If it was necessary to apply a correction for background noise, calculates the pro necessary standards EN ISO 11202 by the following equation

$$K_{1A} = -10 \lg \left(1 - 10^{-0,1\Delta L}\right) \quad dB$$

(5.1)

Eligibility Criterion for Test Environment (K_{2A})

In accordance with the standard ČSN EN ISO 11202, the correction for K_{2A} environment, determined according to Annex A of the standard ČSN EN ISO 3746, must not exceed 7 dB. Relationship for correction determination:

$$K_{2A} = 10\lg\left(1 + 4\frac{S}{A}\right) \quad dB \tag{5.2}$$

where:

S Area of measured surface [m ^{2}]

A A value characterizing the environment properties (sound absorption)

Correction to local environment (*K_{3A}*)

In the sense of Annex A of the standard ČSN EN ISO 11202, the limit of correction determining the accuracy class of the measurement determined in accordance with this annex is equal to 4 dB. Relationship for correction determination:

$$K_{3A} = 10\lg\left(1 + 4\frac{S}{A}\right) \quad dB \tag{5.3}$$

Where

$S = \pi d^2$

D usual distance of operator movement from measured device [m]

A a value characterizing the environment properties (sound absorption)

6.2 Measurment Operating Conditions

Temperature, pressure, humidity

Measured air temperature values operating test environment, barometric pressure in measuring site and relative humidity in measurement site, as determined by independent measuring instruments supplier measurements.

Sound pressure level A

The sound pressure level was measured using Brüel & Kjaer (Denmark) measuring technique. Before the measurement was started, a calibration of the sound level meter was performed and if necessary, adjusted to a 94 dB calibration signal. After every series of measurements was completed, the settings were checked.

Appliances Used Brüel & Kjaer:

- sound level meter type 2250, Art.-No. 3003200, validation certificate no.6035 -OL-Z0087-15, issued on September 30, 2015, valid until 29.9.2017,
- measuring microphone type 4950, Art. 2879941, certificate of verification No. 6035 -OL-M0053-15, issued on 24.9.2015, valid until 23.9.2017,
- acoustic calibrator type 4231, Art. 3006984, Calibration Sheet No. 6035 -KL-K0029-15, issued on September 23, 2015.

Verification and calibration was carried out by ČMI in Brno, the originals of the verification and calibration sheets are stored in supplier's measurement archive. The measuring system complies with IEC 651 and IEC 804 [31].

Measurement results

The resulting sound pressure level A of the device being measured from measurements and in the sense of ČSN EN ISO 11202 also includes the corresponding corrections and the expanded measurement uncertainty according to:

$$L_{pA} = L'_{pA} - K_{1A} - K_{3A} - U \quad dB \tag{5.4}$$

where:

L'_{pA}	average sound pressure level [dB]
K_{1A}	background noise correction [dB]
K_{3A}	local area correction [dB]
$U = 2.53$	expanded measurement uncertainty [dB]

7 DESIGN PART OF INSULATING COVER

The design part of the insulating cover mainly depends on oil pan surrounding area. The design part is carried out by SOLID WORKS software. The surrounding area and the oil pan is shown in the Fig. 7.1.

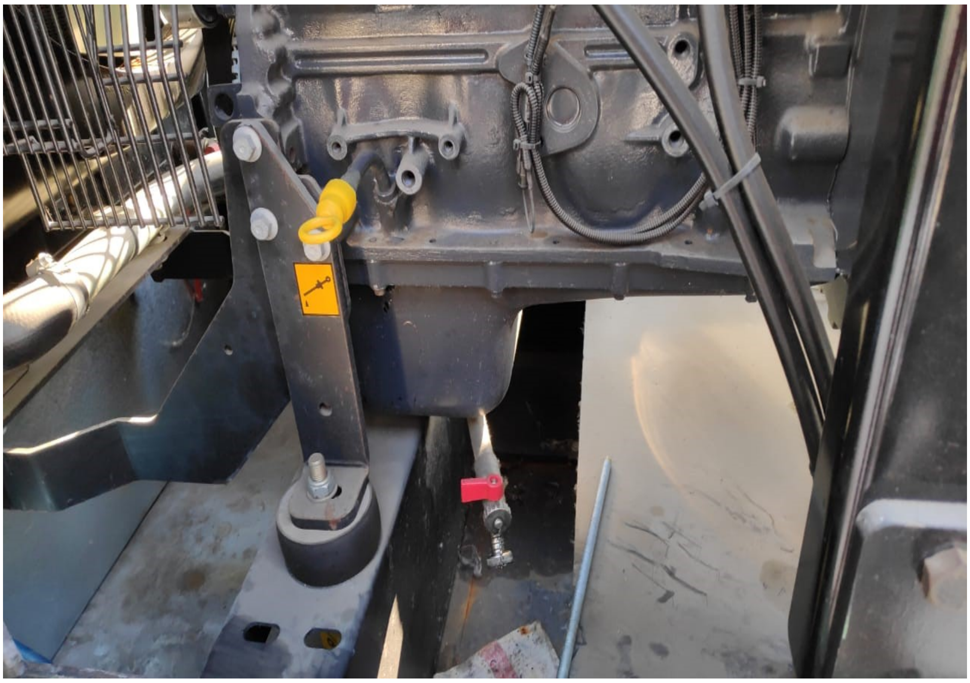

Fig. 7 - Location of Oil pan

Source: Author

7.1 Problem Identified

The main problem that identified was the pipe that goes near to the bottom of the oilpan. So, I have to add that pipe also to design. The design part that includes

- Part Design
- Sketcher
- Assembly Design
- Drafting

7.1.1 Front View

The front view of the design part shows there is an gap for the pipe line which occurs near the oil pan is shown in Fig. 7.2.

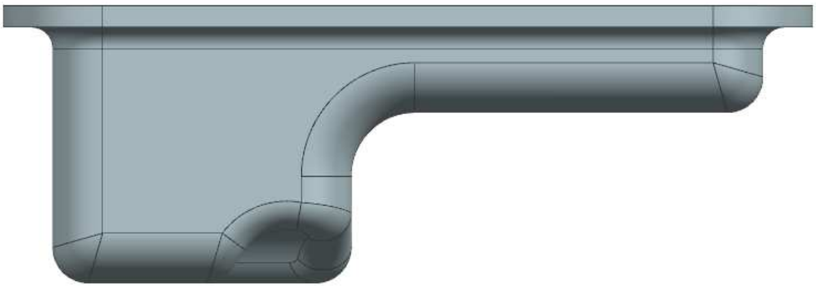

Fig. 8 - Front view of the oil pan cover

Source: Author

7.1.2 Side View

The side view of the design part shows the oilpan cover which is fully dimensional and the gap for the pipe which comes near to the oilpan is at the left edge side as shown in the Fig. 7.3.

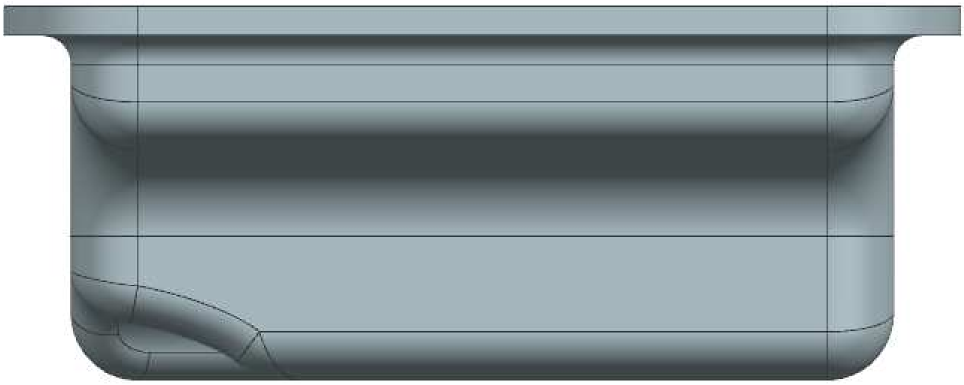

Fig. 9 - Side view of the oil pan cover

Source: Author

7.1.3 Top View

The top view of the oilpan cover shows the gap for the pipe which comes near to the real oil pan and the full dimensional part as shown in the Fig. 7.4.

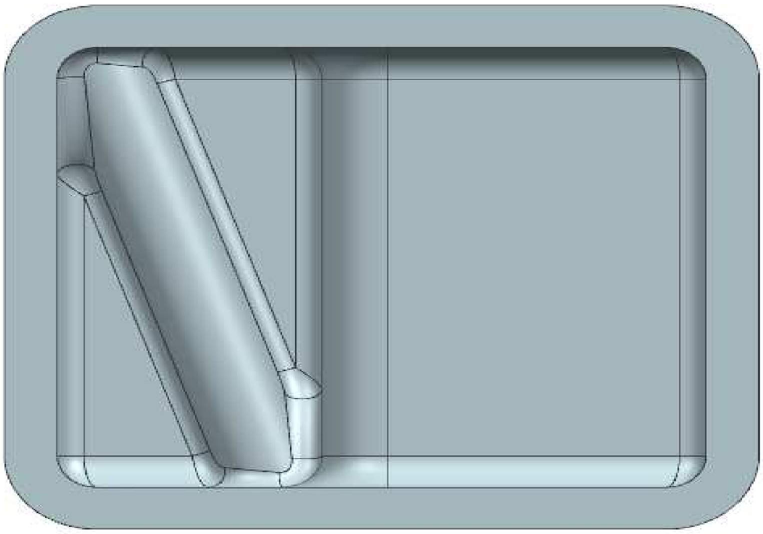

Fig. 10 - Top view of the oil pan cover

Source: Author

7.1.4 Isometric View

Isometric projection is a method for visually representing three-dimensional objects in two dimensions in technical and engineering drawings. It is an axonometric projection in which the three coordinate axes appear equally foreshortened and the angle between any two of them is 120 degrees. The isometric view of the oil pan cover is shown in Fig. 7.5.

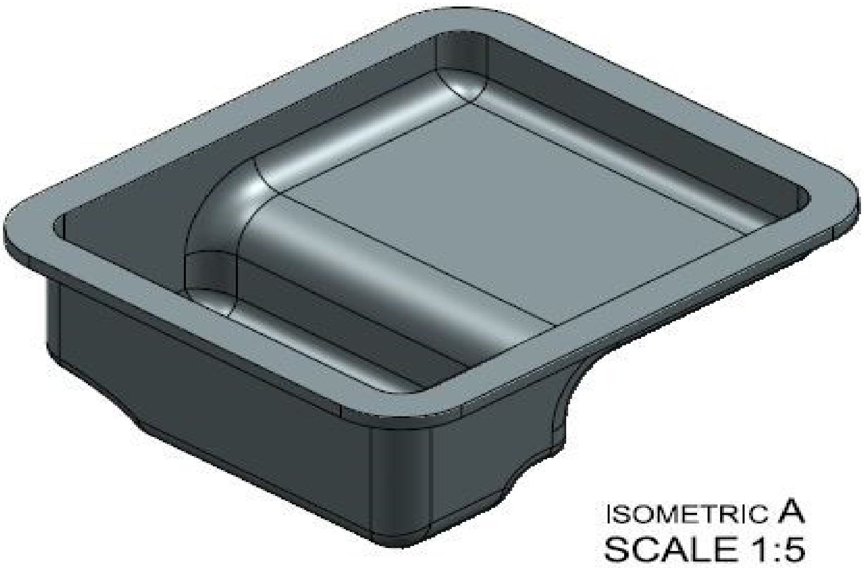

Fig. 11 - Isometric view of the oil pan cover

Source: Author

8 FABRICATION AND INSTALLATION PART OF INSULATING COVER

The fabrication part of the insulating cover requireds the following materials

1. Polystyrene
2. Foam
3. Glue

8.1 Polystyrene

Polystyrene is a flexible fabric used in the production of a broad range of consumer goods. It is often used as a tough, strong plastic in goods requiring consistency, such as food packaging and study ware. Polystyrene is used to create devices, electronics, automotive components, toys, gardening pots and machinery and more when coupled with multiple colors, additives or other materials.

With a comparatively standard free radical chain system, Styrene easily polymerizes to polystyrene. The polymerization would start either by heat or by initiators [32]. Benzoyl peroxide and di-tert-butyl per-benzoate are typically used in the suspension phase. A typical initiator used in emulsion polymerizations was potassium persulfate. Styrene monomer would respond with itself in the presence of inert metals to create a homopolymer.

Polystyrene by quantity of manufacturing was the fourth biggest thermoplastic. It has been used in the following main industries for apps: packaging, consumer / institutional products, electrical / electronic products, construction / construction, furnishings, industrial / machinery and transport [33].

Styrene homopolymers are also referred to as polystyrene, common usage, or glass. Due to the brittleness of glass polystyrene, in the presence of dissolved polybutadiene gum, styrene was commonly polymerized to enhance tissue resistance. Such altered polystyrene has been referred to as polystyrene with high impact, or rubber-modified. High-impact polystyrene styrene content ranges from about 88% to 97%. The item was referred to as an expandable polystyrene where a stirring agent was attached to the polystyrene[33]. The blasting agent may be introduced during or after polymerization as portion of the manufacturing method is shown in Fig. 8.1.

Using glass polystyrene biaxial movie packaging apps include meat and vegetable trays, blister packs and other packaging where clarity was needed. Extruded plastic plates of polystyrene are created into bottles of egg cartons, meat and chicken trays, and boxes of quick meals that require warm or cold storage. Solid polystyrene plates were created into cups and containers for serving and disposable edible packaging. Polystyrene injection shaped grades were widely used in the production of cosmetic and private care bottles, boxes for jewellery and picture tools, and packages for picture films. Other polystyrene products created include fridge door liners, music and video cassettes, toys, flower boxes, photo frames, cooking utensils, TV and radio cabinets, house smoke sensors, computer housings and profile moldings in the construction / home construction industry [34].

Polystyrene is a thermoplastic that is odorless, tasteless and stiff. The following composition is pure polystyrene [32].

Also produced of polystyrene is a fabric called extended polystyrene (EPS) or extruded polystyrene (XPS), prized for its insulating and cushioning characteristics. Foam polystyrene can be more than 95 percent air and is commonly used to create house and appliance fabrics, lightweight protective products, surfboards, food service and food packaging, automotive components, road and roadbank stability devices, and more [34].

Fig. 12 - Polystyrene Brick

Source: https://www.gibbsanddandy.com/ijf07100jabfloor-70-polystyrene-sheet-flooring-insulation-2400-x-1200-x-100mm

8.2 Foam

SoudaFoam Gap Fill was a one-component, selfexpanding, ready to used polyurethane foam with propellants, which is completely harmless to ozone layer [35]. SoudaFoam Gap Fill was available for used with a standard straw applicator, a foam applicator gun, and our patented Genius Gun Applicator is shown in Fig. 8.2.

Table. 2 - Description of Sudafoam

Source: Author

1	Product	SoudaFoam
2	Base	Polyurethane
3	Consistency	Stable Foam
4	Curing System	Moisture-cure
5	Skin Formation (68°F/65% R.H)	7 – 8 minutes
6	Drying Time (68°F/65% R.H)	Dust-free after 20–25 minutes
7	Cellular Structure	70 – 80% closed cell
8	Color	Champagne
9	Insulation Factor	3.9 – 4.1 for 1 inch
10	Water Absorption	1% Vol
11	Shelf Life	18 months
12	Application Temperature	41°F to 95°F
13	Service Temperature	40°F to 194°F

Fig. 13 - Sudafoam Comfort

Source: https://www.hornbach.cz/shop/Montazni-pena-PUR-SOUDAL-Soudafoam-Comfort-GG-DIY-nizkoexpanzni-trubickova-750-ml/6483813/artikl.html

Characteristics:

- Permanent color
- Paintable
- Very good adhesion on many materials
- Very easy application [36]

8.3 Glue

Table. 3 - Description of Mamut Glue

Source: Author

1	Product	Mamut Glue
2	Basis	MS polymer
3	Consistency	thixotropic paste
4	Density g / ml	1.57
5	Heat resistance ° C	40 / +95(after curing)
6	Heat resistance ° C	–15(during transport)
7	Temperature range of use ° C	+5 / +40

Properties

- Immediate holding capacity up to 500 kg / m ^{2}
- High final strength 22 kg / cm ^{2} (220,000 kg / m ^{2})
- High-modulus
- Fast curing, odorless
- High adhesion to the substrate - even on damp substrates
- Permanently flexible, resistant to moisture and water (waterproof joints), weathering
- Free of iso cyanates, solvents, phthalates and silicone
- After curing, paintable with suitable paints (except alkyd resins)
- Glued objects need not be fixed
- The joints "hold" without the uses of clamps and supports [38]

Fig. 14 - Mamut Glue

Source: https://www.hornbach.cz/shop/Lepidlo-DEN-BRAVEN-Mamut-Glue-High-Tack-290-ml-bile/5244616/artikl.html

8.4 Dimensions of Real Oil Pan Module

Full width-49cm, Full length-17.5cm, Bottom box width-20cm, Start curve length-5.8cm, End curve length-4cm, Breadth of box-20cm shown in Fig. 8.4.

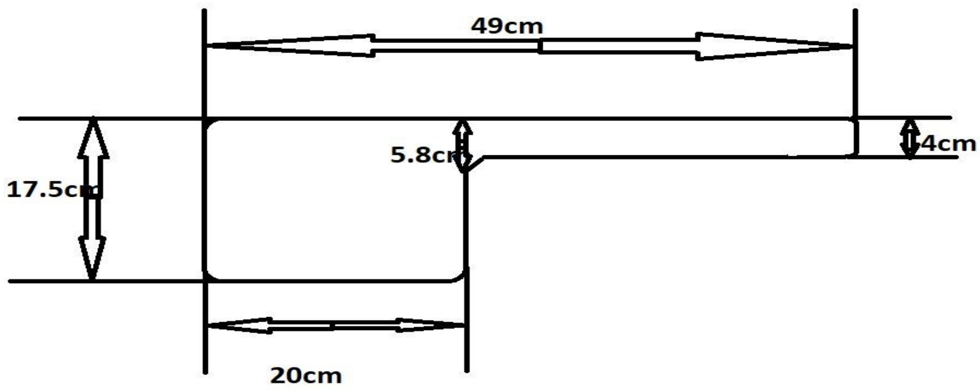

Fig. 15 - Dimensions of real oil pan module

Source: Author

8.5 Fabricated Module

In this fabricated module part the preparation of oil pan cover module according to the above given dimensions by using the polystyrene bricks. The fabricated oil pan module is shown in Fig. 8.5.

Fig. 16 - Fabricated Module of Oil pan Cover

Source: Author

After the fabricated module is fully covered by the Sudafoam spray is shown in Fig. 8.2, after two days the foam will become shapeless material after we have to shape it like the oil pan module. The shape of the foam with the oil pan module is shown in Fig. 8.6.

Fig. 17 - Fabricated Module of Oil pan Cover with Foam

Source: Author

8.6 Installation of Oil Pan Cover

The Installation part of the oil pan cover includes carrying the oil pan cover to ENET Research Institute, VÍTKOVICE where the diesel generator is located. The installation process was carried out about 3 hours with my own hand. It has been complicated to install a full fabricated oil pan cover because of more obstacles are involved like the pipe line which comes near the oil pan and some other rods which also came near. So, I have to cut the fabricated material into four parts thus, I can easily installed the fabricated cover to the real oil pan is shown in Fig. 8.6. After the installation of oil pan cover there will be some small gaps founded that will be covered with cotton fibers are also shown in Fig. 8.7, 8.8.

Fig. 18 - Installed oil pan cover

Source: Author

The other side of the oil pan which is covered by the fabricated material is shown in Fig. 8.8.

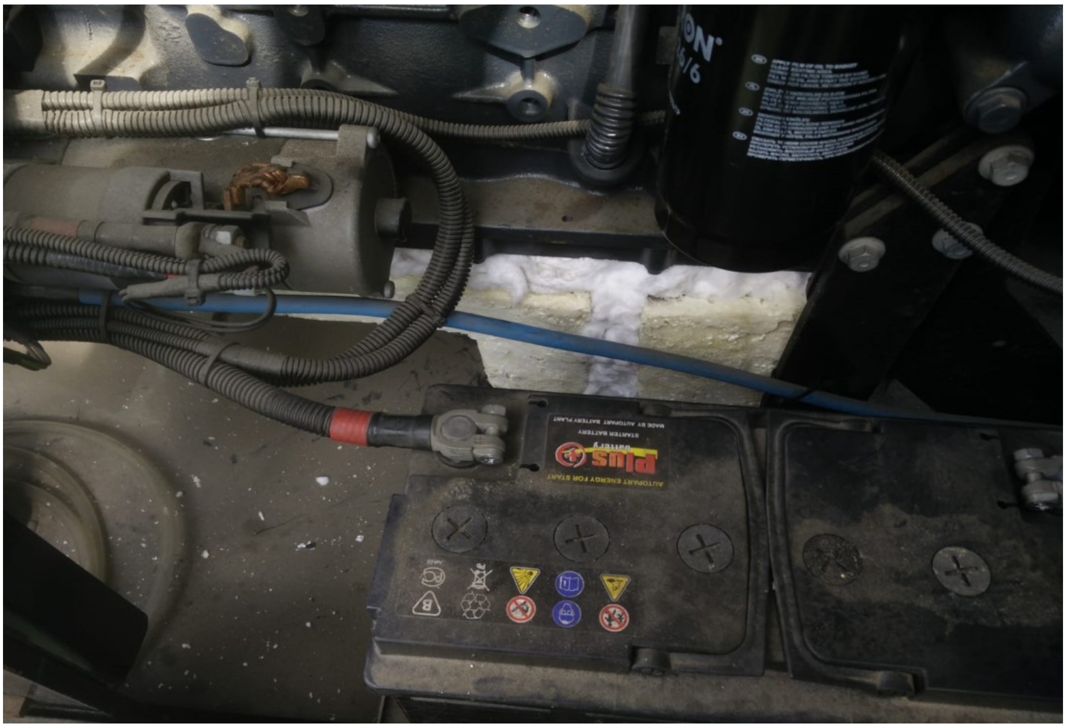

Fig. 19 - Back side of Installed oil pan cover

Source: Author

After the installation of oil pan fabricated cover the cover is fully covered with aluminium foil tape for ensuring the oil pan is fully covered is shown in Fig. 8.9.

Fig. 20 - Oil pan cover with Aluminium foil cover

Source: Author

9 MEASUREMENT OF NOISE IN DIESEL GENERATOR

The measurement of noise in diesel generator is carried out by two levels

- Measurement without oil pan cover
- Measurement with oil pan cover

9.1 Measurement Without Oil Pan Cover

The first level measurement without oil pan cover with open and closed lids was successfully done by using Brüel&Kjær model 2250 sound level analyzer and MIELEC GAS Diesel Generator which is located in ENET Research Institute, VÍTKOVICE is shown in Fig 9.1.

Fig. 21 - Diesel generator with Closed Lids & Brüel&Kjær 2250 Noise meter

Source: Author

9.1.1 Measuring Locations and Measurement Description

This measurement is carried out without the installation of oil pan cover. Records of all data measured by a sound meter, including date and time of measurement, are stored at the noise measurement provider (message processor), and their values are compiled into tables that give unambiguous information is shown in Fig. 9.2.

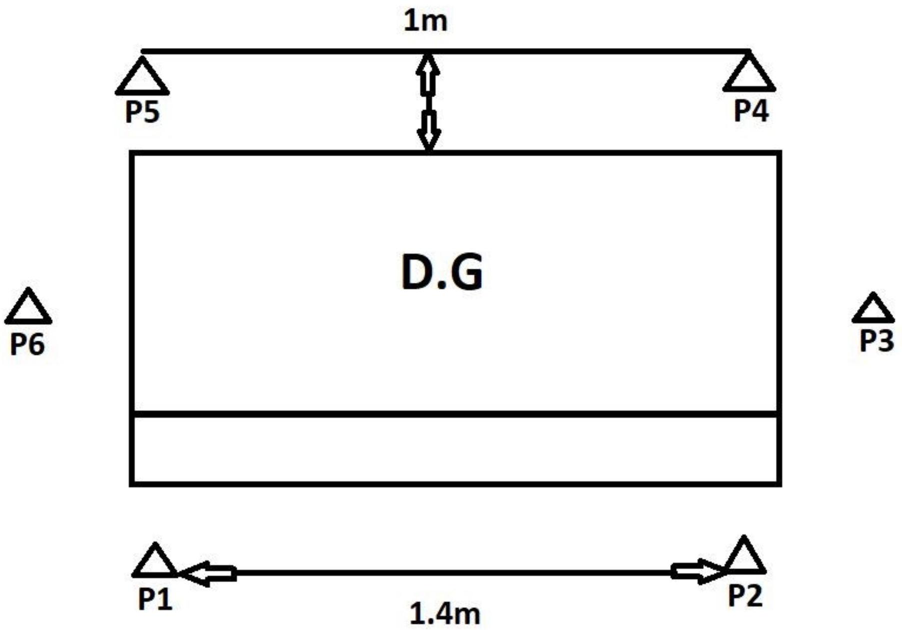

Fig. 22 - Measuring points

Source: Author

- Measuring point No. P 1 – Front left corner to the diesel generator
- Measuring point No. P 2 – Front right corner to the diesel generator
- Measuring point No. P 3 – Right side mid to the diesel generator
- Measuring point No. P 4 – Back right corner to the diesel generator
- Measuring point No. P 5 – Back left corner to the diesel generator
- Measuring point No. P 6 -- Left side mid to the diesel generator

The measuring points were selected at a height of 1.6m above the reflecting plane (floor). Yl of B so determined by 6 reference ch measuring point U (R 1 ÷ 6) to determine hl Adina sound pressure around the diesel generator. The distance between the individual measuring points is less than or equal to 2m.

9.1.2 Peak Noise level Without Oil Pan Cover With Open Lids

The peak noise level (*Lcpeak*) without oil pan cover with open lids was shown in Fig. 9.3.

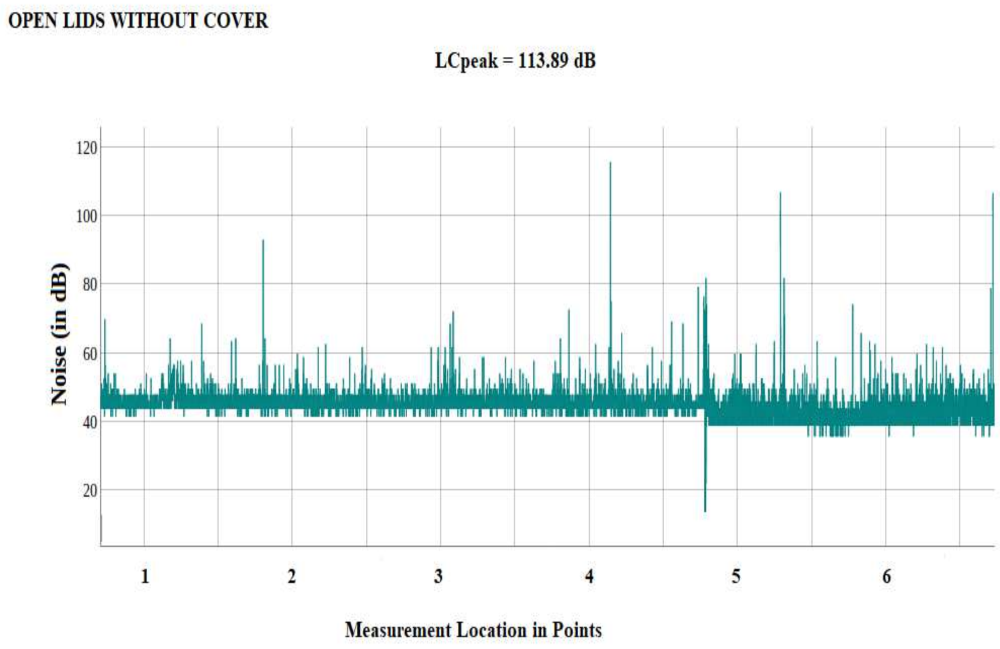

Fig. 23 - Peak noise level (*Lcpeak*) without oil pan cover with open lids

Source: Author

9.1.3 Peak Noise level Without Oil Pan Cover With Closed Lids

The peak noise level (*Lcpeak*) without oil pan cover with open lids was shown in Fig. 9.4.

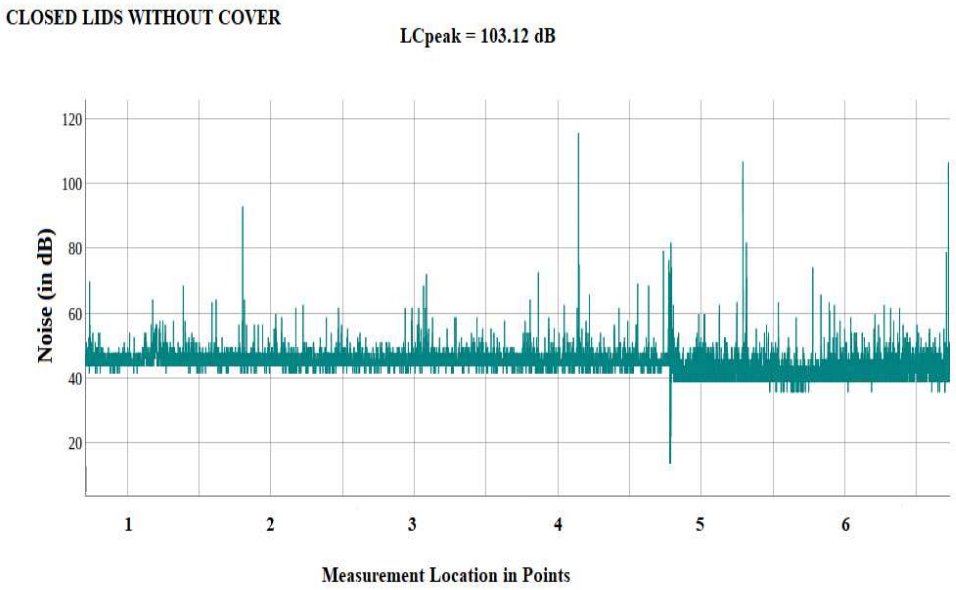

Fig. 24 - Peak noise level (*Lcpeak*) without oil pan cover with closed lids

Source: Author

9.1.4 Measurment Results Without Oil Pan Cover With Open Lids

Table. 4 - Measurement Results without Oil Pan Cover with open lids

Source: Author

MIELEC GAS DIESEL GENERATOR 03-05-2019	Ambient Temperature	t0	14.9	`C
	Biometric Pressure	Pb	97920	Pa
	Relative Air Humidity	O	57.3	%
	Specific Interval	Traffic	Background	
		20	-	S
	Total Measurement Point at One Point	60	-	S
	Number Of Points	6	-	-
	Total Time Of Measurement	420	-	S
	Area Of Measuring Surface	I1	3.8	m
		I2	1.4	m
		I3	1.9	m
		d	1	m
		S	30.4	m2
	Equivalent Area of Space	a	0	m
		b	0	m
		c	0	m
		Sv	0	m2
		a	0	-
		A	0	m2

Measured Data							
Back Ground	dB	Point R1	Point R2	Point R3	Point R4	Point R5	Point R6
	Series A	-	-	-	-	-	-
	Series B	-	-	-	-	-	-
	Series C	-	-	-	-	-	-
Traffic	dB	R1	R2	R3	R4	R5	R6
	Series A	84.70	83.61	87.72	86.74	90.80	97.80
	Series B	85.21	88.72	82.71	91.70	98.71	86.74
	Series C	88.82	89.12	83.81	92.72	98.81	87.94

Calculated Data							
Back Ground	dB	-	-	-	-	-	-
Traffic	dB	86.24	87.15	84.75	90.37	96.11	90.83
Back Ground	dB	-					
Traffic = L'pA	dB	89.38					
Difference in Levels L	dB	-					
Correction K1A	dB	-					
Correction K2A	dB	0.00					
Correction K3A	dB	0.00					

Emission Acoustic Pressure Level A	LpA	90.58
Standard Deviation	~mc ~RO	0.50 1.50
Expansion Factor	K	1.60
Uncertainity of Measurement	u(Lp)	1.58
Uncertainity Widened (CSN EN ISO 11202)	U	2.53
The Resulting Emission Sound Pressure Level A		89.24

9.1.5 Measurment Results Without Oil Pan Cover With Closed Lids

Table. 5 - Measurement Results without Oil Pan Cover with closed lids

Source: Author

MIELEC GAS DIESEL GENERATOR 03-05-2019

Ambient Temperature	t0	14.9	`C
Biometric Pressure	Pb	97920	Pa
Relative Air Humidity	O	57.3	%
Specific Interval	Traffic	Background	
	20	-	s
Total Measurement Point at One Point	60	-	s
Number Of Points	6	-	-
Total Time Of Measurement	420	-	s
Area Of Measuring Surface	I1	3.8	m
	I2	1.4	m
	I3	1.9	m
	d	1	m
	S	30.4	m2
Equivalent Area of Space	a	0	m
	b	0	m
	c	0	m
	Sv	0	m2
	a	0	-
	A	0	m2

Measured Data

	dB	Point R1	Point R2	Point R3	Point R4	Point R5	Point R6
Back Ground	Series A	-	-	-	-	-	-
	Series B	-	-	-	-	-	-
	Series C	-	-	-	-	-	-
Traffic	dB	R1	R2	R3	R4	R5	R6
	Series A	73.00	70.97	68.74	70.58	71.41	72.15
	Series B	72.51	71.47	68.32	71.24	69.05	72.36
	Series C	72.06	70.52	67.02	70.48	70.23	72.01

Calculated Data

Back Ground	dB	-	-	-	-	-	-
Traffic	dB	72.52	70.99	68.03	70.77	70.23	72.17
Back Ground	dB	-					
Traffic = L'pA	dB	70.79					
Difference in Levels L	dB	-					
Correction K1A	dB	-					
Correction K2A	dB	0.00					
Correction K3A	dB	0.00					

Emission Acoustic Pressure Level A	LpA	71.58
Standard Deviation	~mc	0.50
	~RO	1.50
Expansion Factor	K	1.60
Uncertainity of Measurement	u(Lp)	1.58
Uncertainity Widened (CSN EN ISO 11202)	U	2.53
The Resulting Emission Sound Pressure Level A		70.78

9.2 Measurement With Oil Pan Cover

The final level measurement with oil pan cover in open and closed lids was successfully done by using Brüel&Kjær model 2250 sound level analyzer and MIELEC GAS Diesel Generator which is located in ENET Research Institute, VÍTKOVICE is shown in Fig. 9.5.

Fig. 25 - Diesel generator with Open Lids & Brüel&Kjær 2250 Noise meter

Source: Author

9.2.1 Measuring Locations and Measurement Description

This measurement is carried out without the installation of oil pan cover. Records of all data measured by a sound meter, including date and time of measurement, are stored at the noise measurement provider (message processor), and their values are compiled into tables that give unambiguous information is shown in Fig. 9.6.

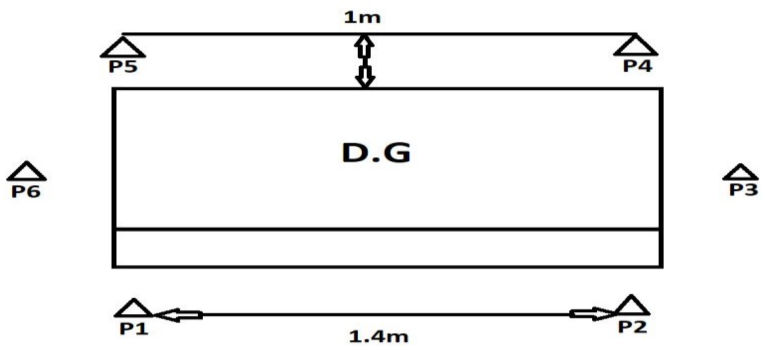

Fig. 26 - Measuring points

Source: Author

- Measuring point No. P 1 – Front left corner to the diesel generator
- Measuring point No. P 2 – Front right corner to the diesel generator
- Measuring point No. P 3 – Right side mid to the diesel generator
- Measuring point No. P 4 – Back right corner to the diesel generator
- Measuring point No. P 5 – Back left corner to the diesel generator
- Measuring point No. P 6 -- Left side mid to the diesel generator

The measuring points were selected at a height of 1.6m above the reflecting plane (floor). Yl of B so determined by 6 reference ch measuring point U (R 1 ÷ 6) to determine hl Adina sound pressure around the diesel generator. The distance between the individual measuring points is less than or equal to 2m.

9.2.2 Peak Noise level With Oil Pan Cover With Open Lids

The peak noise level (*Lcpeak*) without oil pan cover with open lids was shown in Fig. 9.7.

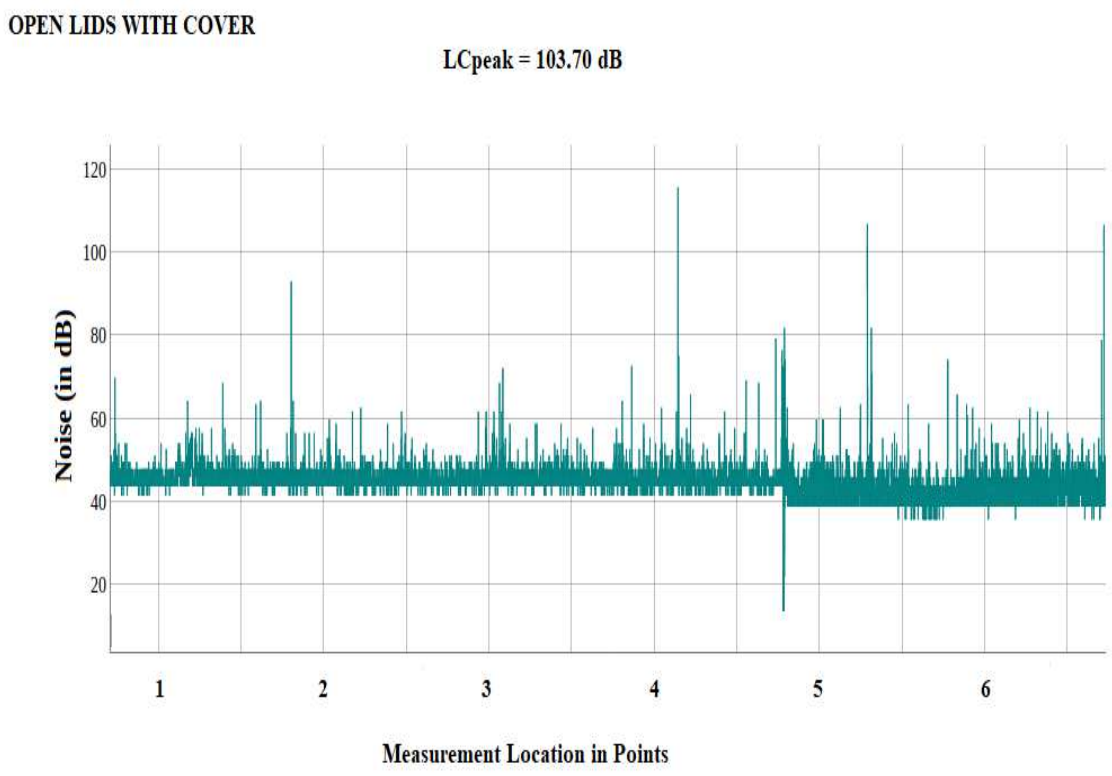

Fig. 27 - Peak noise level (*Lcpeak*) with oil pan cover with open lids

Source: Author

9.2.3 Peak Noise level With Oil Pan Cover With Closed Lids

The peak noise level (*Lcpeak*) with oil pan cover with closed lids was shown in Fig. 9.8.

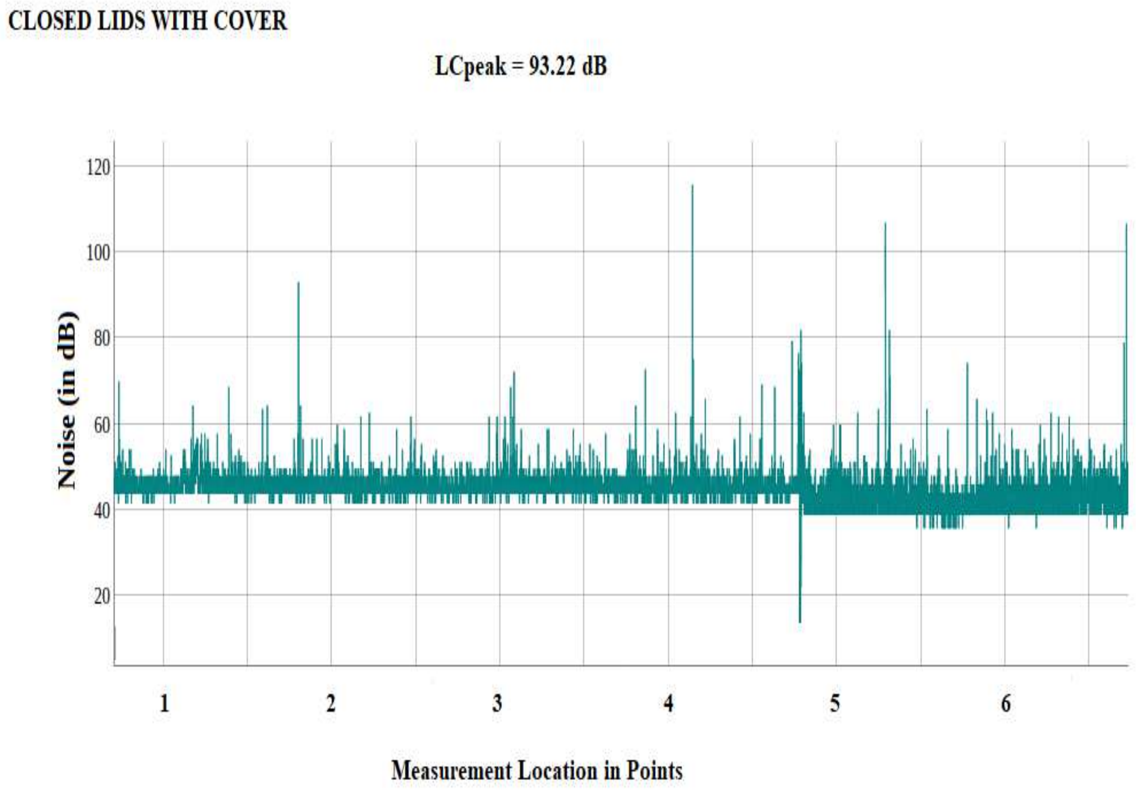

Fig. 28 - Peak noise level (*Lcpeak*) with oil pan cover with closed lids

Source: Author

9.2.4 Measurment Result With Oil Pan Cover With Open Lids

Table. 6 - Measurement Result with Oil Pan Cover with open lids

Source: Author

MIELEC GAS DIESEL GENERATOR 03-05-2019				
	Ambient Temperature	t0	14.9	`C
	Biometric Pressure	Pb	97920	Pa
	Relative Air Humidity	O	57.3	%
	Specific Interval	Traffic	Background	
		20	-	S
	Total Measurement Point at One Point	60	-	S
	Number Of Points	6	-	-
	Total Time Of Measurement	420	-	S
	Area Of Measuring Surface	I1	3.8	m
		I2	1.4	m
		I3	1.9	m
		d	1	m
		S	30.4	m2
	Equivalent Area of Space	a	0	m
		b	0	m
		c	0	m
		Sv	0	m2
		a	0	-
		A	0	m2

Measured Data							
Back Ground	dB	Point R1	Point R2	Point R3	Point R4	Point R5	Point R6
	Series A	-	-	-	-	-	-
	Series B	-	-	-	-	-	-
	Series C	-	-	-	-	-	-
Traffic	dB	R1	R2	R3	R4	R5	R6
	Series A	75.82	82.85	85.87	75.42	82.62	80.85
	Series B	75.42	83.14	85.62	74.72	84.74	80.14
	Series C	75.15	82.42	85.12	74.12	76.13	78.72
Calculated Data							
Back Ground	dB	-	-	-	-	-	-
Traffic	dB	75.46	82.80	85.54	74.75	81.16	79.90
Back Ground	dB	-					
Traffic = L'pA	dB	79.95					
Difference in Levels L	dB	-					
Correction K1A	dB	-					
Correction K2A	dB	0.00					
Correction K3A	dB	0.00					

Emission Acoustic Pressure Level A	LpA	81.15
Standard Deviation	~mc ~RO	0.50 1.50
Expansion Factor	K	1.60
Uncertainity of Measurement	u(Lp)	1.58
Uncertainity Widened (CSN EN ISO 11202)	U	2.53
The Resulting Emission Sound Pressure Level A		79.91

9.2.5 Measurment Result With Oil Pan Cover With Closed Lids

Table. 7 - Measurement Result with Oil Pan Cover with Closed lids

Source: Author

MIELEC GAS DIESEL GENERATOR 03-05-2019				
	Ambient Temperature	t0	14.9	`C
	Biometric Pressure	Pb	97920	Pa
	Relative Air Humidity	O	57.3	%
	Specific Interval	Traffic	Background	
		20	-	S
	Total Measurement Point at One Point	60	-	S
	Number Of Points	6	-	-
	Total Time Of Measurement	420	-	S
	Area Of Measuring Surface	I1	3.8	m
		I2	1.4	m
		I3	1.9	m
		d	1	m
		S	30.4	m2
	Equivalent Area of Space	a	0	m
		b	0	m
		c	0	m
		Sv	0	m2
		a	0	-
		A	0	m2

Measured Data

	dB	Point R1	Point R2	Point R3	Point R4	Point R5	Point R6
Back Ground	Series A	-	-	-	-	-	-
	Series B	-	-	-	-	-	-
	Series C	-	-	-	-	-	-
Traffic	dB	R1	R2	R3	R4	R5	R6
	Series A	63.52	59.68	60.58	61.12	63.88	59.59
	Series B	61.12	63.58	59.52	59.13	61.25	59.78
	Series C	63.62	60.68	59.42	61.15	59.18	64.02

Calculated Data

Back Ground	dB	-	-	-	-	-	-
Traffic	dB	62.75	61.31	59.84	60.47	61.44	61.13
Back Ground	dB	-					
Traffic = L'pA	dB	61.16					
Difference in Levels L	dB	-					
Correction K1A	dB	-					
Correction K2A	dB	0.00					
Correction K3A	dB	0.00					

Emission Acoustic Pressure Level A	LpA	62.78
Standard Deviation	~mc	0.50
	~RO	1.50
Expansion Factor	K	1.60
Uncertainity of Measurement	u(Lp)	1.58
Uncertainity Widened (CSN EN ISO 11202)	U	2.53
The Resulting Emission Sound Pressure Level A		61.15

9.3 Comparison of Measurement Results

- From the above comparison of measurement result tables, measurement result with oil pan cover with closed lids [7] and measurement result without oil pan cover with closed lids [5] shows that Final resulting emission sound pressure level (A) = Resulting emission sound pressure level (A) measurement result without oil pan cover with closed lids (-) Resulting emission sound pressure level (A) measurement result with oil pan cover with closed lids

  Final resulting emission sound pressure level (A) for closed lids = 70.78 - 61.15 (dB)

  Final resulting emission sound pressure level (A) for closed lids = 9.63 (dB)

- From the above comparison of measurement result tables, measurement result with oil pan cover with open lids [6] and measurement result without oil pan cover with open lids [4] shows that Final resulting emission sound pressure level (A) = Resulting emission sound pressure level (A) measurement result without oil pan cover with open lids (-) Resulting emission sound pressure level (A) measurement result with oil pan cover with open lids

  Final resulting emission sound pressure level (A) for open lids = 89.24 – 79.91 (dB)

  Final resulting emission sound pressure level (A) for open lids = 9.33 (dB)

9.4 Proposal for Further Implementation

From the above comparison of the measurement tables, there will be more than 10% of the resulting emission sound pressure level is reduced. So, I am proposing this technique to diesel generator manufacturing companies to add this technique at the time of installing the diesel generator and also make the oil pan cover with harder materials compare to polystyrene. It could give a better results comparing to the above measurement results and also for the students who are interested in doing research in reducing noise in IC Engine, this paper will helps for their needs and also, I suggest to the students and also the companies to take measurement while using this technique to other kind of diesel generators at different environmental conditions.

10 CONCLUSION

Challenges of man are many but it can be alienated. Most of those challenges are avoidable some are necessary evil. The need of electricity is a necessity to all both rich and poor. Handling the effect of generators noise simply means termination of the source. This can only be done if the major source of power supply are made better or probably constant. Generating plants is one of the major sources of noise pollution. Virtually every building has generator that was frequently used. A problem known is a problem half solved but our reaction as individual and a nation was reluctantly, slowly, and often inadequately. Generator noise have no positive side, it have no rhythm, pattern nor sequence; all it carries are important public health problem that could lead to hearing loss, sleep disruption, cardiovascular disease, social handicaps, reduce productivity, impaired teaching and learning, absenteeism, increased drug use, and accidents. It could impair the ability to enjoy one's property and leisure time and increases the frequency of antisocial behaviour [11].

From the above comparison of measurement result tables, measurement result with oil pan cover with closed lids [7] and measurement result without oil pan cover with closed lids [5], shows that the resulting emission sound pressure level (A) for with oil pan cover with closed lids has 9.63 dB less than the resulting emission sound pressure level (A) for without oil pan cover with closed lids and also from the comparison of measurement result tables, measurement result with oil pan cover with open lids [6] and measurement result without oil pan cover with open lids [4], shows that the resulting emission sound pressure level (A) for with oil pan cover with open lids has 9.33 dB less than the resulting emission sound pressure level (A) for without oil pan cover with open lids. Thus, from my diploma thesis concludes that about more than 10% of the normal noise level from the diesel generator is reduced by using oil pan cover technique.

According to the theoritical part, the most of the noise from the IC Engine comes from Head region like from Valve Train, Timing Chain, Connecting Rod, Crankshaft Bearing, Piston Slap, Piston Pin. So, we have to focused mainly on that region to reduce noise level and also recommended that generator owner should building acoustic barrier and insulation made of rigid materials with significant mass and stiffness such as sheet steel, sand-filled block walls or solid concrete walls. These also reduced the transmission of sound.

REFERENCES

[1] RAJENDRA KUMAR KAUSHIK, P. K. (2015).A Review on a Noise Reduction System in IC Engine.International Journal of Engineering Sciences & Research Technology, 2015.

[2] TUNG V.T.C. and CROCKER M.J. Diesel engine noise and relationship to cylinder pressure. S.A.E. Technical paper series, 1982, ISSN: 820237.

[3] RUSSEL M.F. and HAWORTH R. Combustion noise from high speed direct injection engines. S.A.E. Technical paper series, 1985, ISSN: 850973.

[4] EL BADAOUI, M., DANIÈRE, J., GUILLET, F. and SERVIÈRE, C.Separation of combustion noise and piston-slap in diesel engine-Part I: Separation of combustion noise and pistonslap in diesel engine by cyclic Wiener filtering, Mechanical System and Signal Processing 19, 2005, ISSN:1209-1217.

[5] YOGESH V MORANKAR , PROF. M. R.Noise Reduction of a Diesel Engine A Review, International Journal of Engineering Research & Technology (IJERT), 2014, ISSN:2278-0181.

[6] ROHRLE M D. Affecting diesel engine noise by the piston. SAE paper, 1975, ISSN:750799.

[7] AGARWAL, S. K. Pollution Management. Noise Pollution, 2002, ISSN:136-138.

[8] GOINES, L, HAGLER, L. Noise Pollution: A Modern Plague. Southern Medical Journal, 2007, ISSN:287-293.

[9] BERGLUND, B. and LINDVALL, T. “Community Noise”. Archives of the Center for Sensory Research, 1995, ISSN:21195.

[10] HARUNA A. Grinding machine noise spectra in Kaduna metropolis, Nigeria Journal of environmental Issues and Agriculture in Developing Countries, 2011, ISSN:157-164.

[11] STEPHEN A. S. and MARK P. M. Noise pollution: non-auditory effects on health British Medical Bulletin Asian Journal of Engineering, Sciences & Technology, VOL. 3, 2003.

[12] FIELDS J. M. 1984. The effect of numbers of noise events on people’s reactions to noise. An analysis of existing survey data. J AcoustSoc Am, 1984, ISSN:447–67.

[13] ROBINSON, D.W. Noise Exposure and Hearing: A New Look At The Experimental Data. Health and Safety Executive Research report, H.M.S.O, 1987, ISSN: 447-68.

[14] DOBIE, R.A. Medical-Legal Evaluation of Hearing Loss. New York, Van Nostrand Reinhold, 1993.

[15] MAREK ROLAND-MIESZKOWSKI, Common Misconceptions About Hearing Digital Recordings -Advanced R & D 5959 Spring Garden Rd., Suite 1103, Halifax, Nova Scotia, B3H-1Y5, Canada, 1994, ISSN: 429-9622.

[16] STANLEY, A.M. Air Pollutants Concentration and Noise Levels from Electric Power Generators. Seminar Presented at the Seminar Series of Faculty of Environmental Design, Ahmadu Bello University, Zaria, 2010.

[17] SIS, Swedish Standards Institute [online]. Copyright © 14.04.2019]. Available from: https://www.sis.se/api/document/preview/912224/

[18] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: https://www.sis.se/api/document/preview/76179/

[19] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 1996-1, Acoustics - Description, measurement and assessment of environmental noise - Part 1: Basic quantities and assessment procedures.

[20] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 3534-2, Statistics - Vocabulary and symbols - Part 2: Applied statistics.

[21] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 3741, Acoustics - Sound Power Levels and Sound Energy Levels Using Sound Pressure - Precision Methods for Reverberation Test Rooms.

[22] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 3743-1, Acoustics - Determination of sound power levels of noise sources.

[23] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 3743-2, Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering methods for small sources in reverberant fields.

[24] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 3747, Acoustics - Determination of Sound Power Levels and Sound Energy Levels Using Sound Pressure.

[25] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 4871, Acoustics - Declaration and verification of noise emission values for machinery and equipment.

[26] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 6926, Acoustics - Requirements for performance and calibration of sound sources used for determination of sound power levels.

[27] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 7574-1, Acoustics - Statistical methods for determining and verifying the noise emission values of machinery and equipment.

[28] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 11200, Acoustics - Noise emitted by machinery and equipment.

[29] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 11202, Acoustics - Noise emitted by machinery and equipment - Determination of emission sound pressure levels.

[30] SIS, Swedish Standards Institute [online]. Copyright © E [cit. 14.04.2019]. Available from: http://ISO 11203, Acoustics - Noise emitted by machinery and equipment - Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level.

[31] [online]. Copyright©Pl[cit. 14.04.2019]. Availablefrom: https://www.bksv.com/downloads/2250/be1712.pdf

[32] VDMA, Kenndaten für die Verarbeitung thermoplasticher Kunststoffe, Pt. I, Thermodynamik, Hanser, Munich, 1979.

[33] LF ALBRIGHT, Processes for Major Addition Type Plastics and Their Monomers, McGraw-Hill, New York, 1974.

[34] EL BECHSTIEN, PULLMAN KELLOGG, Houston, TX, to MR Clowers, US Environmental Protection Agency, Research Triangle Park, NC, 1978.

[35] D. WEAIRE, S. HUTZLER, "The Physics of Foams", Oxford University Press, 1999, ISSN: 0198510977.

[36] I. CANTAT, S. COHEN-ADDAD, F. ELIAS, F. GRANER, R. HOHLER, O. PITOIS, F. ROUYER, A. SAINT-JAMES, & QUOT; Foams: Structure & Dynamics & quot; SJ Cox, 2013, ISSN: 9780199662890.

[37] WILSON, AJ, "Principles of Foam Formation and Stability." Foams: Physics, Chemistry, and Structure. New York, Springer-Verlag, 1989, ISSN: 9780199662890.

[38] KINLOCH, AJ. Adhesion and Adhesives: Science and Technology (Reprinted ed.). London: Chapman and Hall. p. 1. 1987. ISSN: 0-412-27440-X.

[39] [online]. Availablefrom: https://www.denbraven.cz/produkt/mamut-glue-high-tack/

[40] WADLEY, LYN. "Compound Adhesive Manufacture Inc. and Behavioral Proxy for Complex Cognition in the Middle Stone Age". Current Anthropology. 2010. 51 (s1): S111-S119. doi: 10.1086 / 649836.

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